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13. ABSTRACT (Maximum 200 words) The proposed research had two main purposes. The first was to develop simple, adaptive, and distributed energy control (transmission power and transmission rate control) algorithms that (i) control the topology of wireless <i>ad hoc</i> communication networks, subject to traffic with diverse bandwidth and end-to-end quality of service requirements, in a spectrally and energy efficient manner; (ii) control multiple access interference and adapt to time-varying propagation losses; and (iii) combine with transmission scheduling, media access control, and multi-hop routing. The second is to design simple, efficient, and robust mechanisms to improve the performance of Transmission Control Protocol (TCP) in mixed wired/wireless communication and ad-hoc networks. The basic approach is to study how the soon-to-be-standardized Selective Acknowledgement feature of TCP, together with knowledge of the statistical behavior of wireless links, can be used to decouple the error recovery and flow control functions of TCP by distinguishing between congestion and non-congestion related packet loss.				
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The research results are summarized below:

The next generations of wireless personal communication systems are expected to serve the high bandwidth demands of new multimedia applications. In our work, the current standards: IS-95, CDMA2000 1x-EV and UMTS were analyzed and the need for more spectrum efficient methods in order to service multiple high-rate connections within a cell site at the same time was addressed from a systems level.

The search for a better algorithm for packet scheduling and power allocation, i.e. the allocation of resources in the uplink (from wireless station to base-station) lead to the introduction of a novel scheme with better spectrum efficiency compared to regular CDMA networks with perfect power control algorithms.

A similar scheduling and power allocation algorithm was also developed for the downlink (from base-station to the wireless station). Both the algorithm for downlink and uplink were simulated and compared with regular CDMA schemes in Mathematica environment with realistic channel models. The total throughput of a cell site with the suggested algorithm outperformed regular CDMA both in uplink and downlink. The performances were measured for various cell conditions with various channel conditions, channel models, cell-sizes and maximum allowable power levels.

To further understand the behavior of the suggested scheme, the patterns that emerged as a result of various interference levels were analyzed. Besides throughput, the average power consumption within a cell site is a major concern since it introduces inter-cell interference to neighboring cells and therefore degrades the total network performance. The total power consumption of the suggested scheme is calculated through analytical methods and later simulated in Mathematica to support the analytical results. Compared to regular CDMA, the suggested scheme used less power or the same power level depending on the inter-cell interference level, intra-cell interference level, thermal noise and channel conditions.

In our earlier analysis we let single connections have as high rates as necessary to maximize the total throughput within the cell. Although the QoS (Quality of Service) requirements were part of the constraint set, we neglected some jitter requirements that are inherent in practical networks (such as voice data can only have around 100msec of jitter in order to avoid human ear to notice any delays). In order to be able to apply the suggested scheme to networks in practice, the theoretical optimum algorithm was modified in order to include only the allowed rates from the rate set of CDMA2000 1x-EV, the maximum power levels allowed were also modified accordingly. The modified scheme, which has the added benefit of satisfying the jitter requirements were then analyzed and compared with regular CDMA. The performance gains measured were reduced compared to the theoretical optimum as expected but the suggested scheme still outperformed regular CDMA by a significant amount.

Research Publications:

"Dynamic spreading gain control in multiservice CDMA networks," Seong-Jun Oh, Wasserman, K.M., IEEE Journal on Selected Areas in Communications, Volume 17, Issue 5, May 1999, Pages 918-927.

"Integration of voice and data traffic in CDMA networks using > dynamic spreading gain control," Seong-Jun Oh, Wasserman, K.M., IEEE International Conference on Communications (ICC 98) Conference Record, 1998, Volume 2, Pages 968-972. vol.2.

"Adaptive resource management for DS-CDMA networks subject to . > energy constraints," Seong-Jun Oh, Wasserman, K.M., Seventeenth Annual Joint Conference of the IEEE Computer and Communications Societies (Proceedings INFOCOM '98) IEEE, Volume 2, 1998, Pages 556-563, vol.2.

"Spreading gain control in random access direct-sequence spread-spectrum data networks," Seong-Jun Oh, Wasserman, K.M., IEEE 6th International Conference on Universal Personal Communications, Conference Record.

"Transmission schemes for time-varying wireless channels with partial state observations," Danlu Zhang, Wasserman, K.M., INFOCOM 2002. Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies (Proceedings) IEEE, Volume 2, 2002, Pages 467-476

"Analysis on markov modeling of cellular packet transmission," Danlu Zhang, Wei Biao Wu, Wasserman, K.M., Wireless Communications and Networking Conference (WCNC2002), IEEE, Volume 2, Mar 2002, Pages 876-880

"Energy efficient data communication over fading channels," Danlu Zhang, Wasserman, K.M., Wireless Communications and Networking Conference (WCNC 2000) IEEE, 2000, Pages 986-991, vol.3

"Distributed power control and spreading gain allocation in CDMA data networks," Seong-Jun Oh, Olsen, T.L., Wasserman, K.M., Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies (Proceedings INFOCOM 2000) IEEE, Volume 2, 2000, Pages 379-385 vol.2

"Dynamic spreading gain control in multiservice CDMA networks," Seong-Jun Oh, Wasserman, K.M., IEEE Journal on Selected Areas in Communications, Volume 17, Issue 5, May 1999, Pages 918-927

"Adaptive resource allocation in power constrained CDMA mobile networks," Seong-Jun Oh, Wasserman, K.M., Wireless Communications and Networking Conference, (WCNC 1999) IEEE 1999, Pages 510-514 vol.1